

Analysis and prediction of hazards associated with thunderstorm for UAS operations

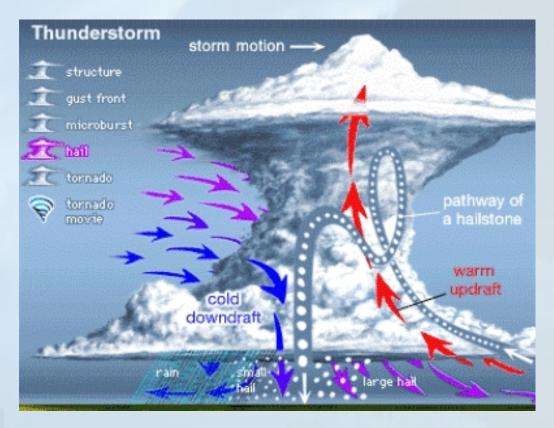
James Pinto NCAR/RAL

National Center for Atmospheric Research

Outline

NCAR

- Characteristics of Convective Storms
- Convective Storm Prediction
- Prediction of Hazards Associated with Convection

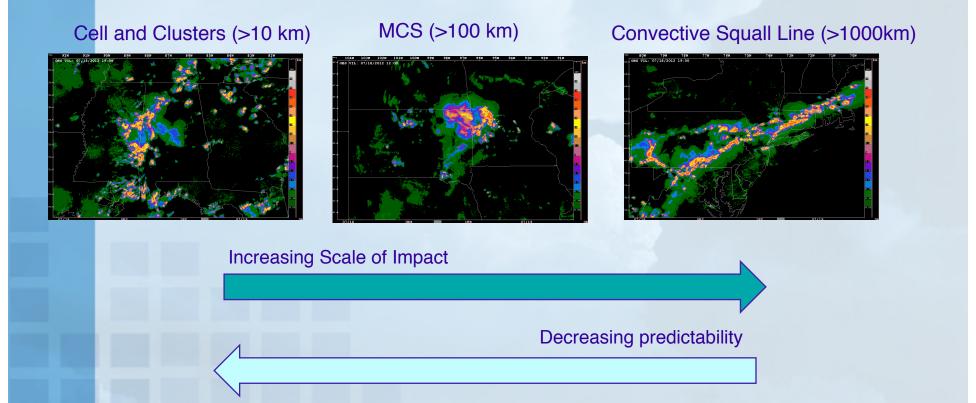


Thunderstorms!



Aviation Weather Center Collaborative Convective Forecast Product (CCFP)

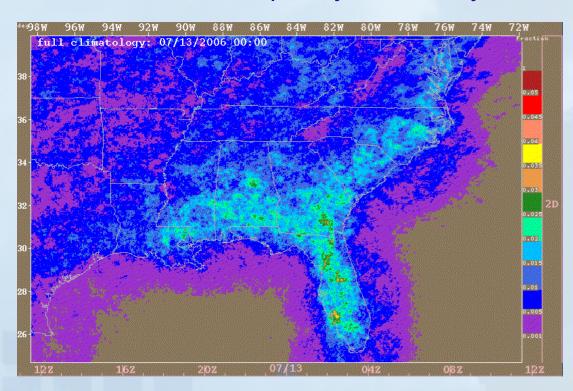
- At least 3000 square miles, and
- A coverage of at least 25% with echoes of at least 40 dbz composite reflectivity, and
- A coverage of at least 25% with echo tops of at least 25,000 feet MSL





Diurnal Cycle of Summertime Thunderstorms

Southeastern U.S. Frequency Reflectivity > 40 dBZ



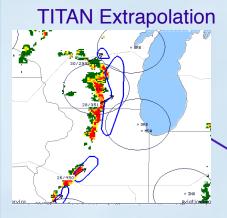


Hazards Associated with Thunderstorms

- Low-altitude Turbulence potential loss of flight control
- Vertical shear potential loss of lift
- ➤ Sudden wind shifts flight planning difficulties
- Strong winds loss of flight control
- Heavy rain damage electronics / reduce prop efficiency, impacts visibility
- ➤ Lightning RF interference can impact communications
- Microburst catastrophic loss of flight control
- ➤ Hail severe damage to aircraft

Thunderstorm Prediction

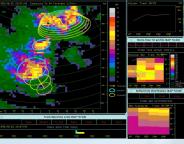




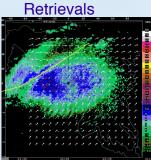
Autonowcaster 0-2 hr forecasts

Storm Trends......





FINECAST Wind

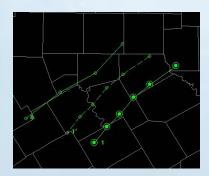


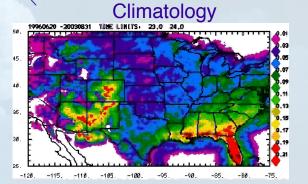
Cloud Monitoring



Forecaster Boundaries







Thunderstorm Prediction

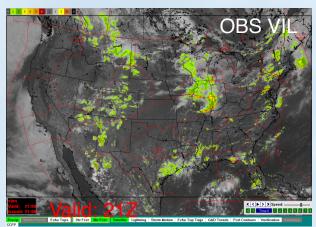
NCAR

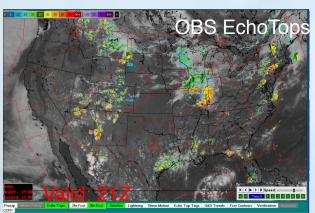
Consolidated Storm Prediction for Aviation (CoSPA) 0-8 hours

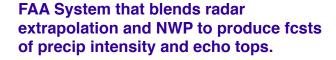
















- ➤ Analysis include satellite, lightning, radar data
- **>** 0-8 hours
- > 3 km resolution
- > 15 min update rate / output frequency
- > Overlays for aviation planning

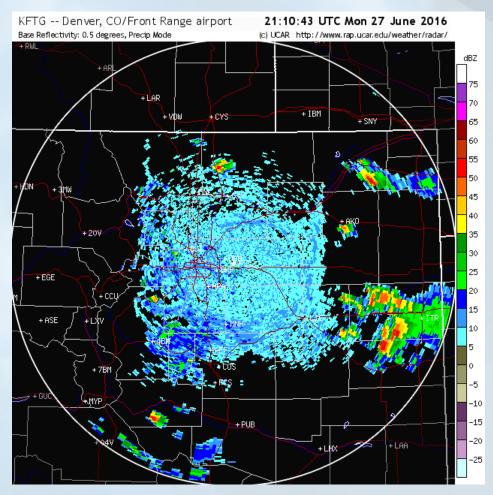
Analysis and prediction of ancillary hazards





Ancillary Storm Hazards:

- Sudden wind shifts
- Low-altitude turbulence
- New initiation along boundaries
- Vertical shear above gust fronts
- Microbursts

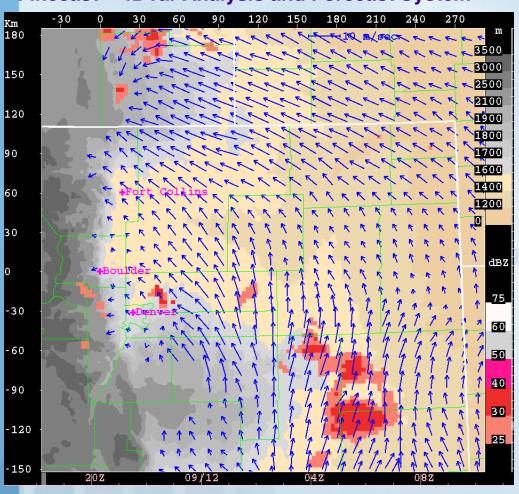


Wind shift boundaries



Why is it a hazard?
Sudden shift in wind direction can send UAS off-coarse

Finecast – 4DVar Analysis and Forecast System



Assimilates:

- radar reflectivity & Radial velocity
- Surface station data
- Profiler
- Satellite data

Heavy Rain

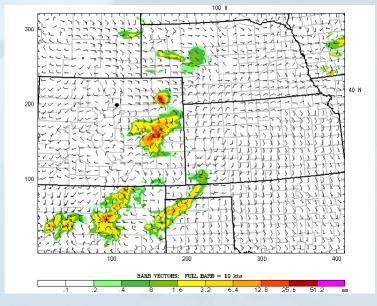
NCAR

Why is it a hazard?
Reduce propeller efficiency, avionics failure, reduced visibility



NCAR Systems
TITAN – tracking
CoSPA – analysis and prediction
WRF – model development work (PBL, microphysics)

WRF 6 hr Rain Intensity Forecast



Precip using physics developed in RAL

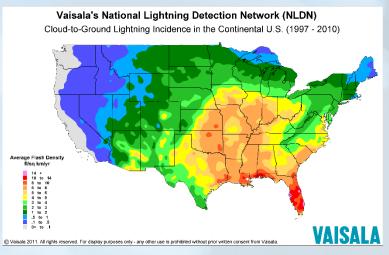
Lightning

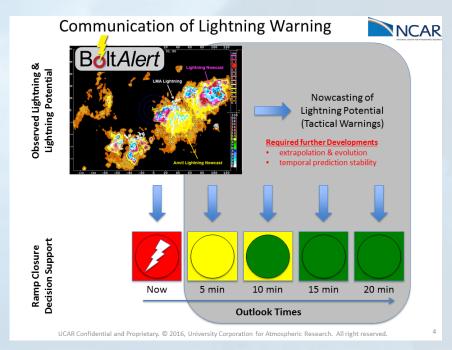
Why is it a hazard?
RF interference can cause loss of comms.
UASs not designed to dissipate charge?



Systems
CoSPA – analysis and prediction
NLDN, 3D Lightning, Bolt Alert

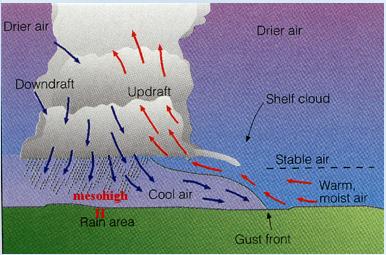
Relative Frequency of Lightning Strikes NCAR





Vertical shear

Why is it a hazard?
Can knock UAS off course or cause loss of control

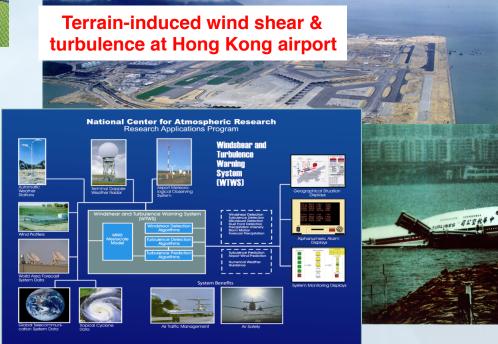


Density current showing change of wind with height

Systems - Examples

- Ramp events example from wind energy
- Juneau / Hong Kong wind shear alert systems

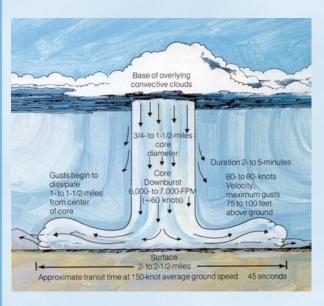




Microburst

Why is it a hazard?

Can knock UAS off course or cause loss of control



Winds exceeding 30 mph, gusts greater than 50 mph Sudden severe changes in vertical motions

Systems

- NCAR LLWAS
- MIT-LL TDWR



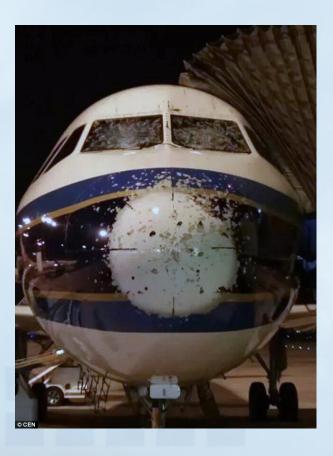
MIT-LL TDWR



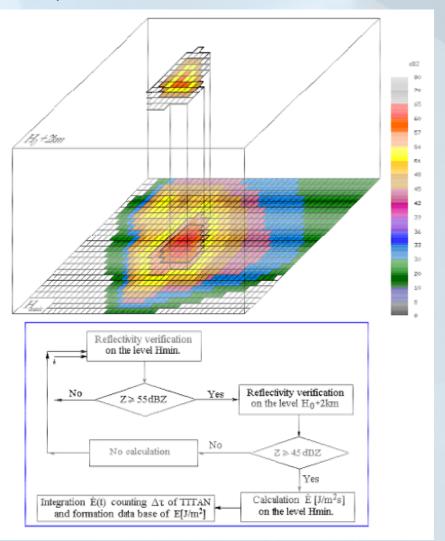


Hail

Why is it a hazard? Catastropic damage to fuselage



Systems NCAR
TITAN – tracking & detection algorithms
Dual-polarization enhanced detection



Summary of Hazards



Hazard	Damage to UAV	Performance	Operations
Heavy rain	2	2	2
Strong winds	1	3	3
Sudden wind shifts	1	3	3
Lightning	2	3	3
Vertical Shear	3	5	3
Hail	5	5	5
Microburst	5	5	5

Scale: 1= concern,5 = catastrophic Table sorted by impact to operations

Hazards can extend far from location of thunderstorm (e.g., wind patterns, comms interference from lightning)

Summary

NCAR

- > Thunderstorms present multiple hazards for UAS
- ➤ NCAR/RAL has technologies for prediction of TS & associated hazards that can be tailored to meet UAS needs
- ➤ Goal is to work with potential users to develop decision support tools for efficient and safe operation of UAS

Future Capability: Prediction / display of convective hazards for a region of interest.

